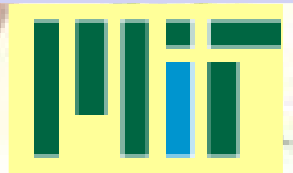
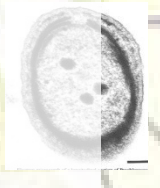
Regulation of phytoplankton diversity by ocean physics

- Who lives where and when? Why?
- Impact on biogeochemical cycles?
- *What controls diversity?*

Mick Follows, Andrew Barton,Stephanie Dutkiewicz, Jason Bragg, Sallie Chisholm, Chris Hill, Oliver Jahn

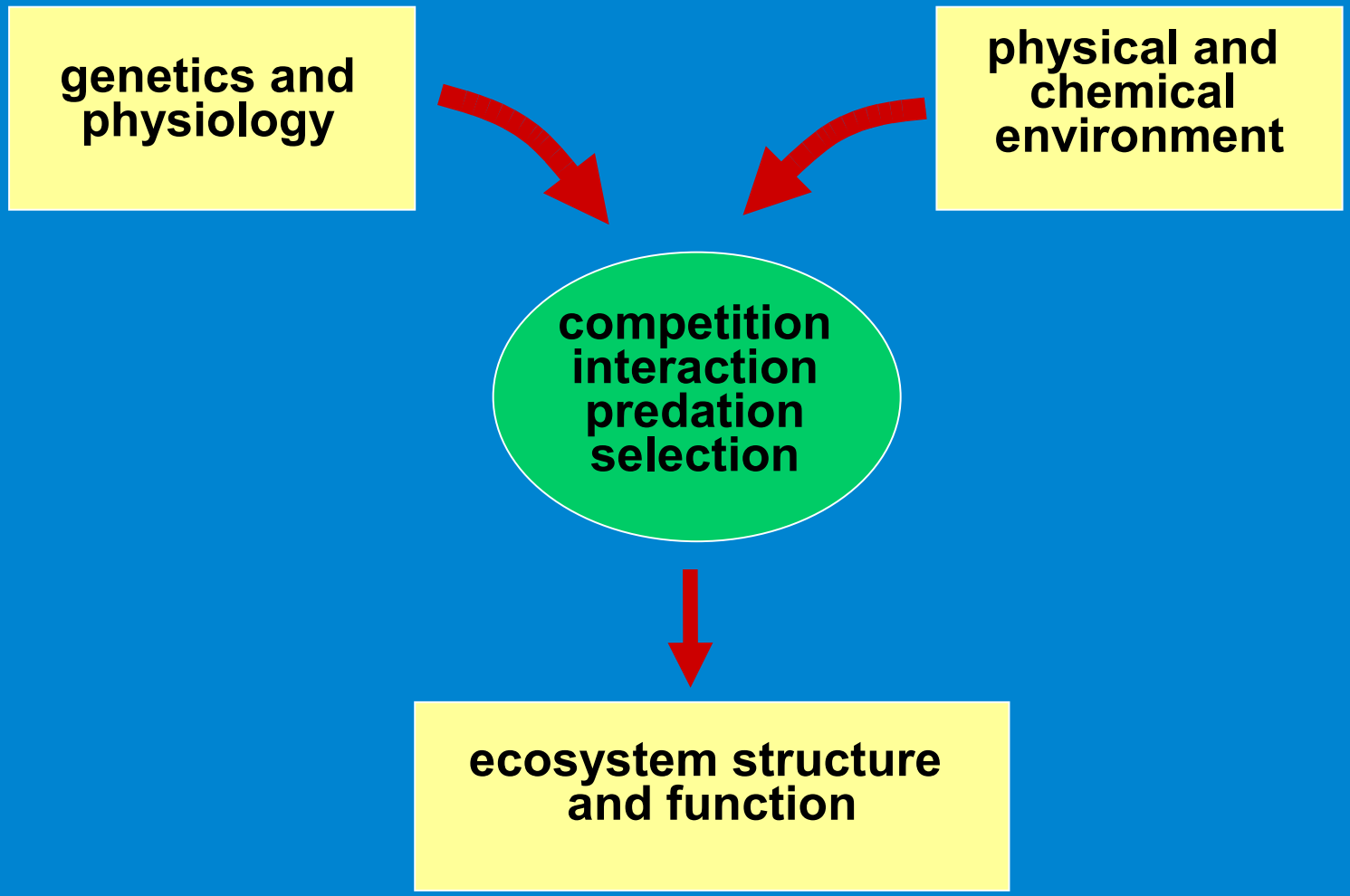


Outline



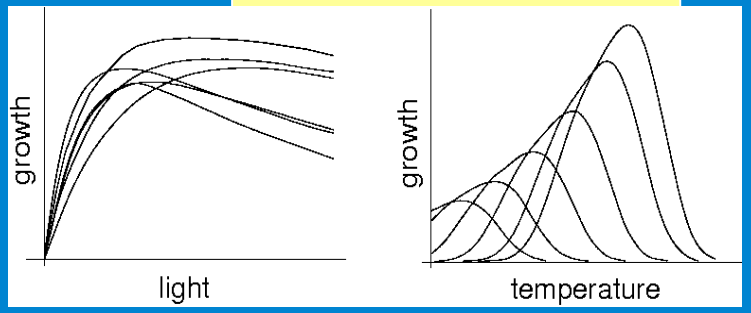
- Organization of marine ecosystems
- Self-assembling model phytoplankton communities
  - models based on ECCO circulation products
- Patterns of co-existence and diversity
  - role of advection

Organization of Ecosystems



An organizing principle for models of marine ecosystems

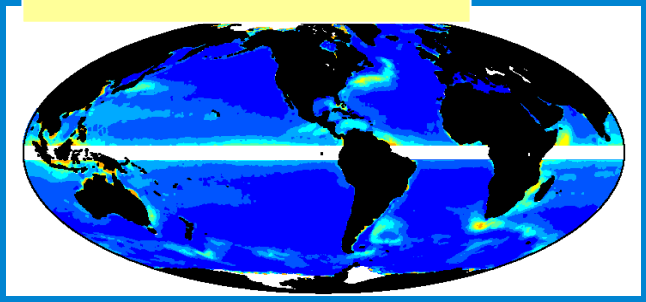
genetics and physiology



ny 10s of initialized phyto types.
chastically assigned
siological characteristics

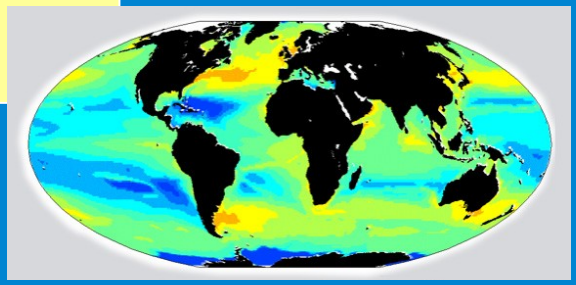
competition
interaction
predation
selection

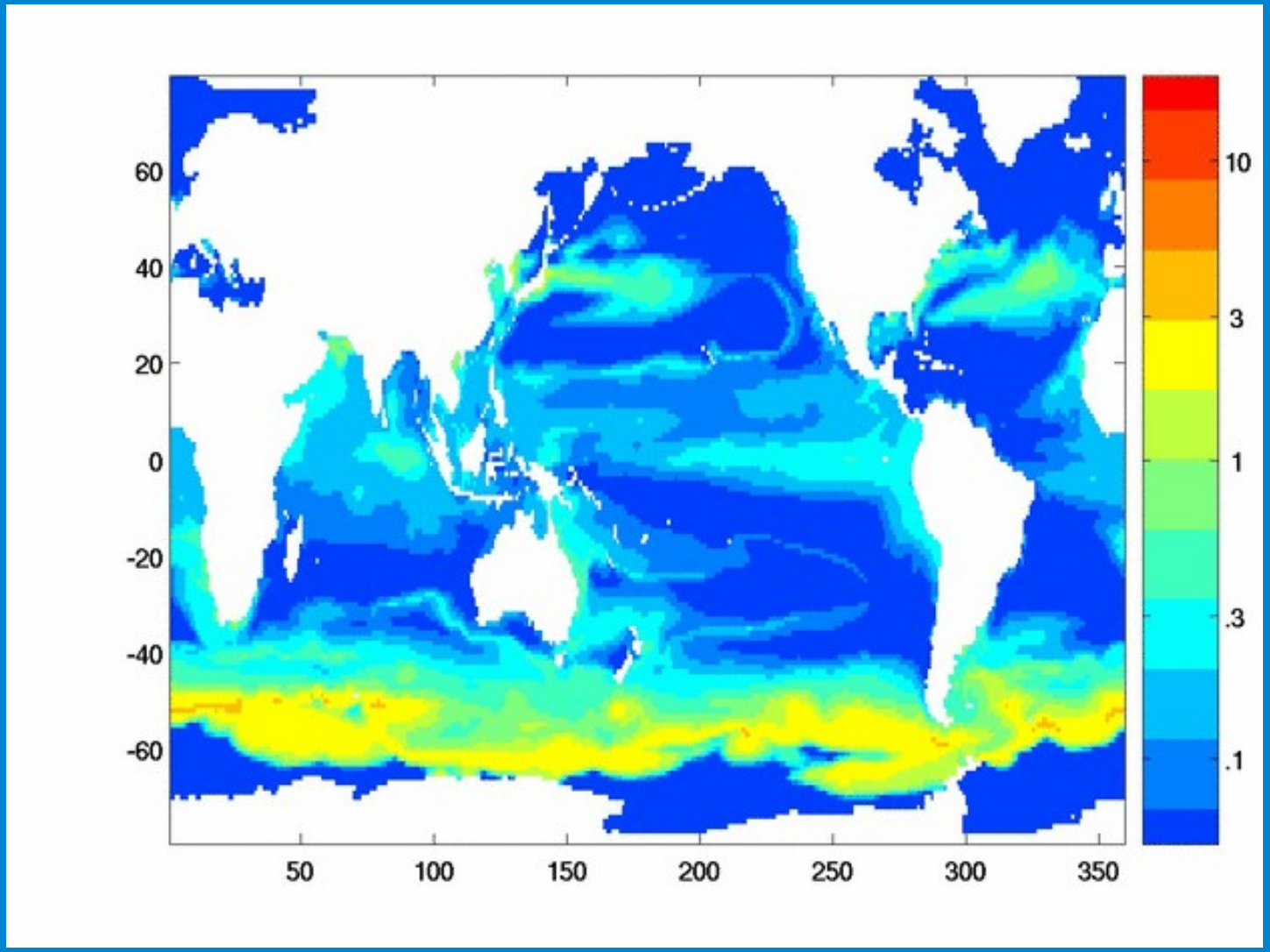
physical and chemical environment



ECCO ocean circulation
N, P, Fe, Si cycles

ecosystem structure and function





Modeled 0-50m biomass (uM N)

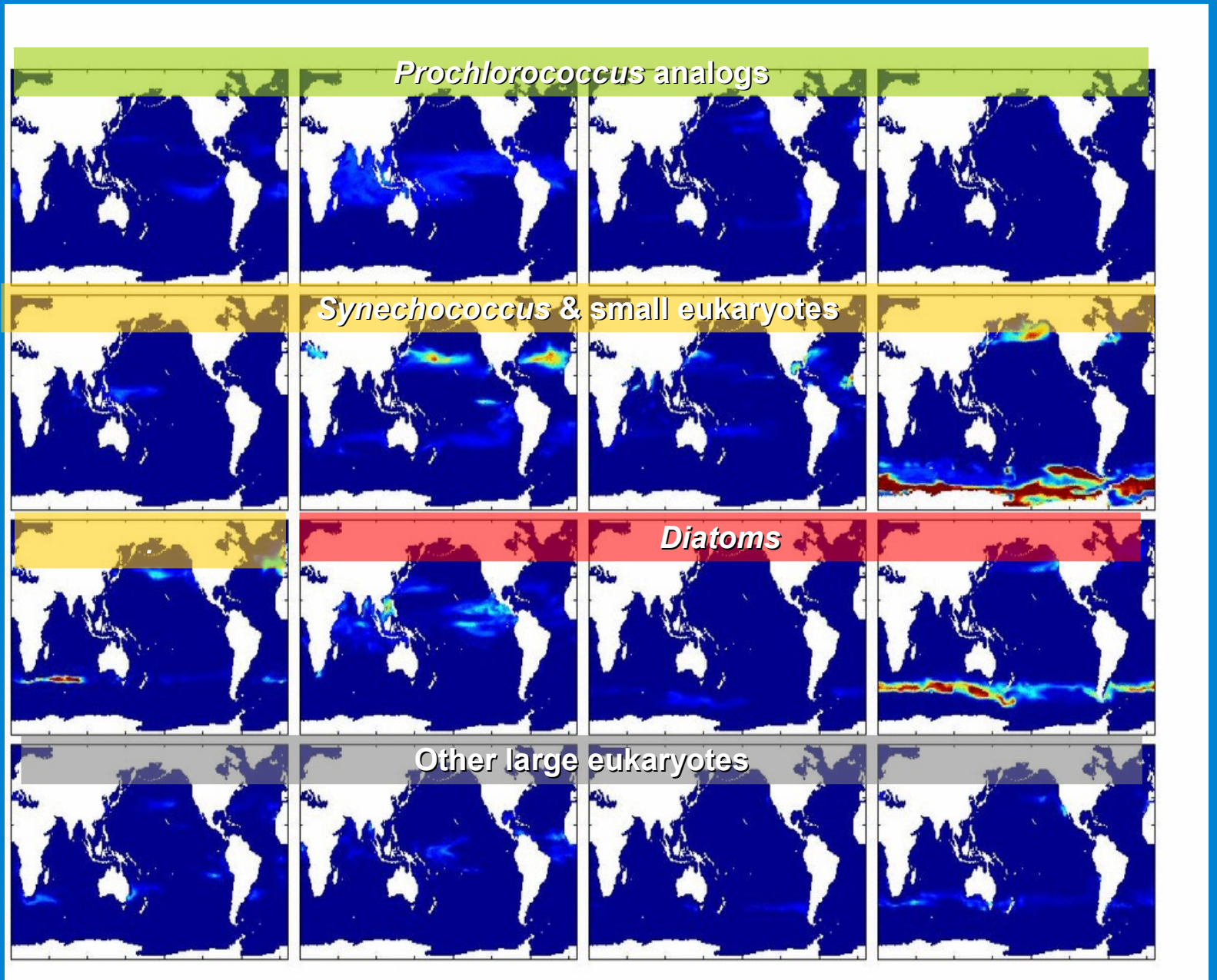
- ECCO-GODAE 1x1 circulation state estimate
- Sum of contributions from 78 types of phytoplankton

Biomass, 0-50m

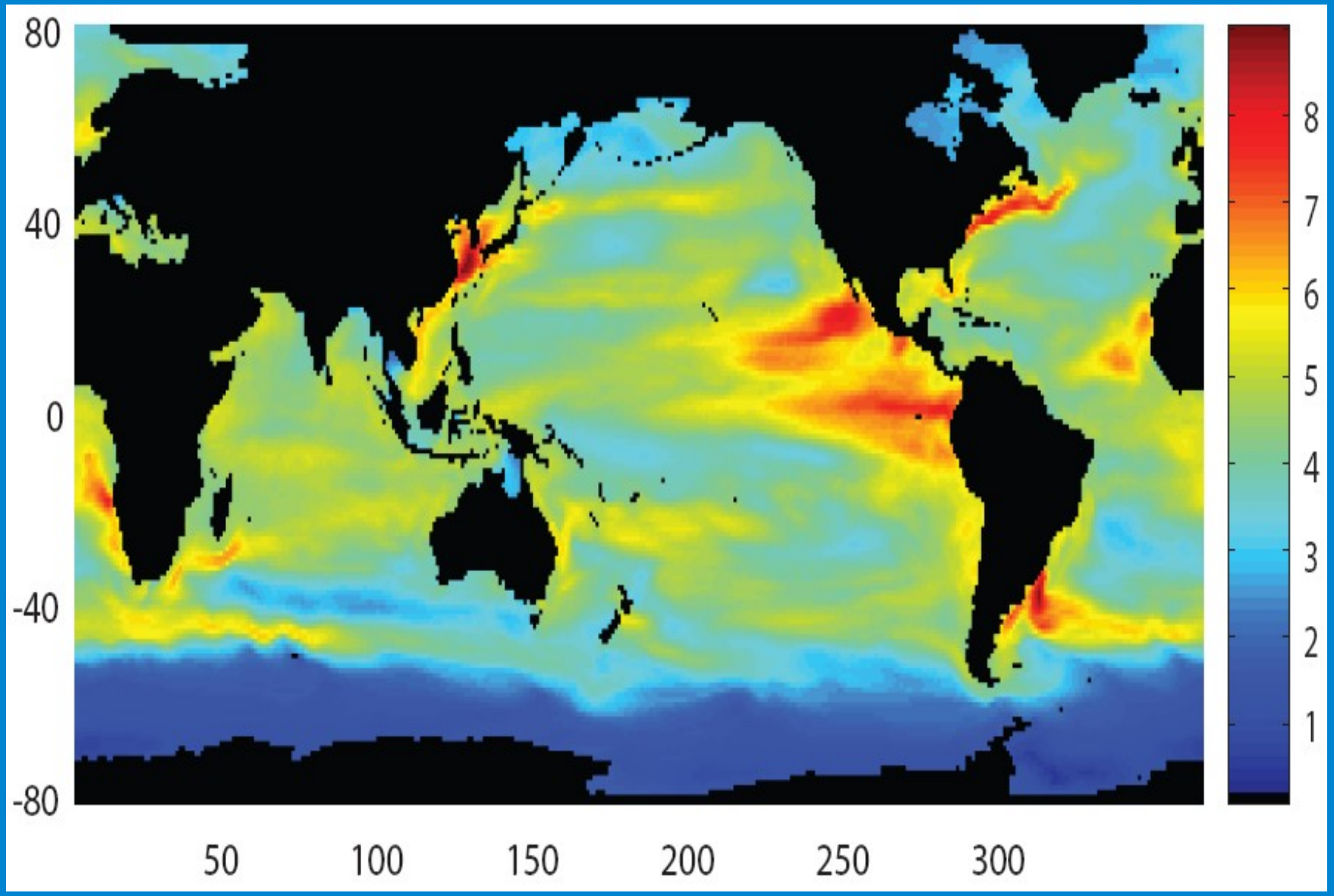
78 initialized phytoplankton types

Relative fitness organizes...

- 16 most abundant account for >99% biomass

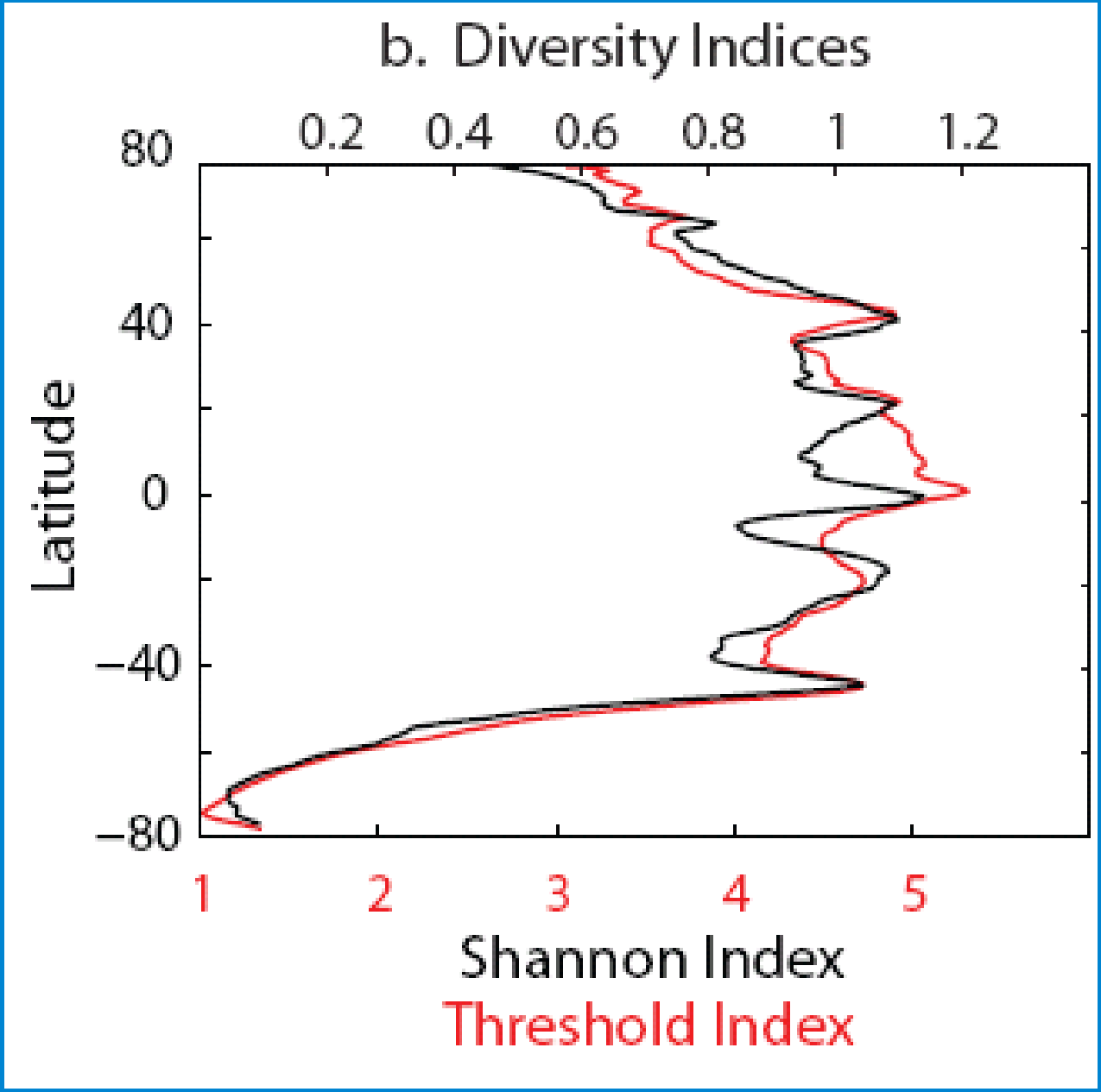


Patterns of Co-existence/Diversity

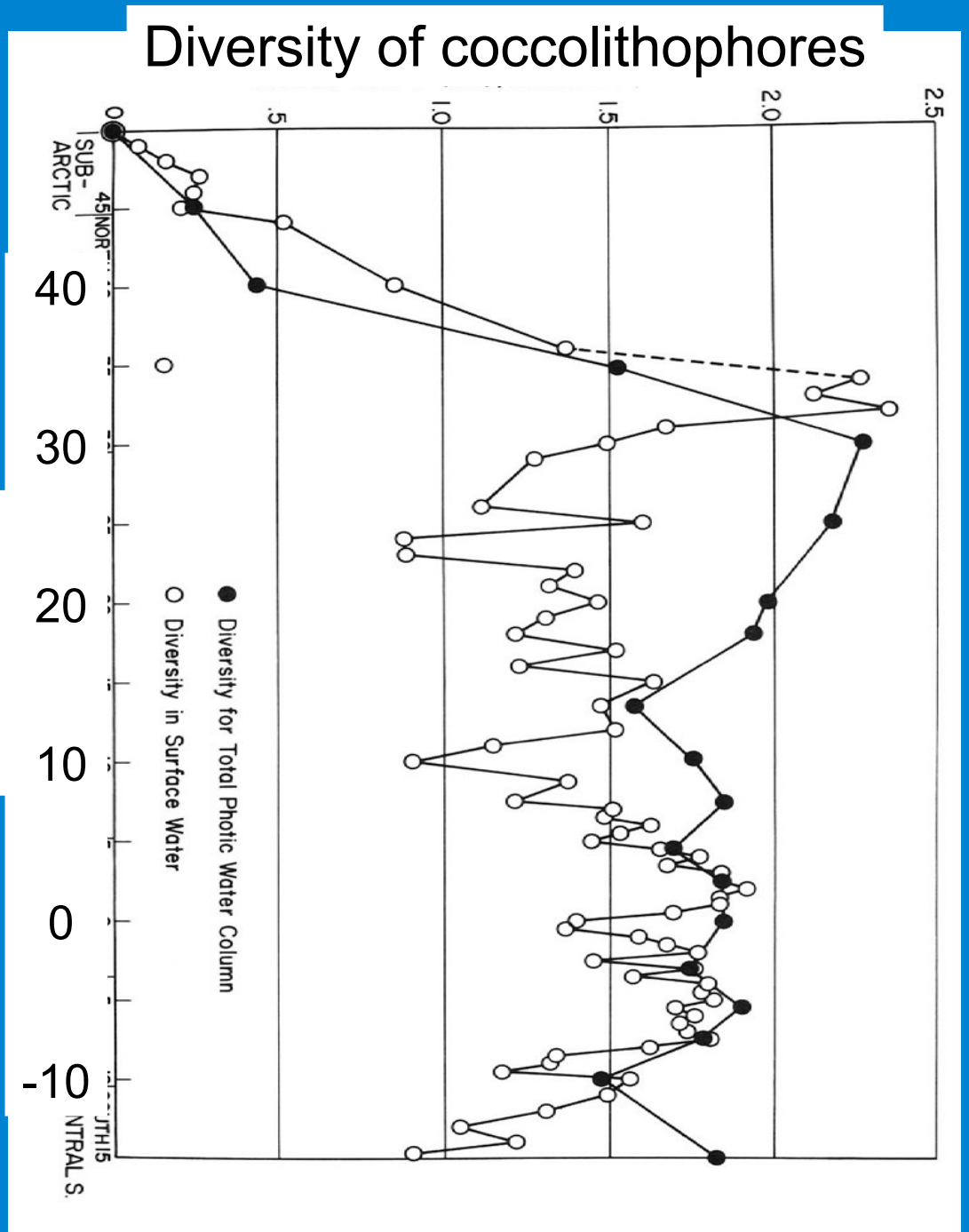


ECCO-GODAE 1x1 degree circulation

Model's zonally averaged diversity of phytoplankton

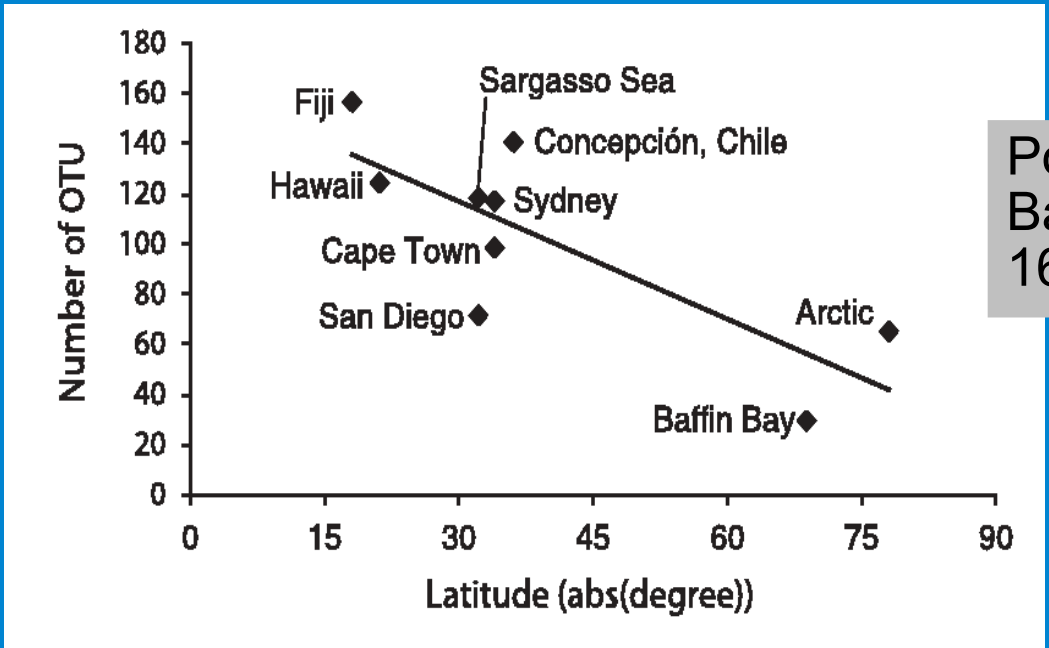


Observed gradients in marine microbial diversity



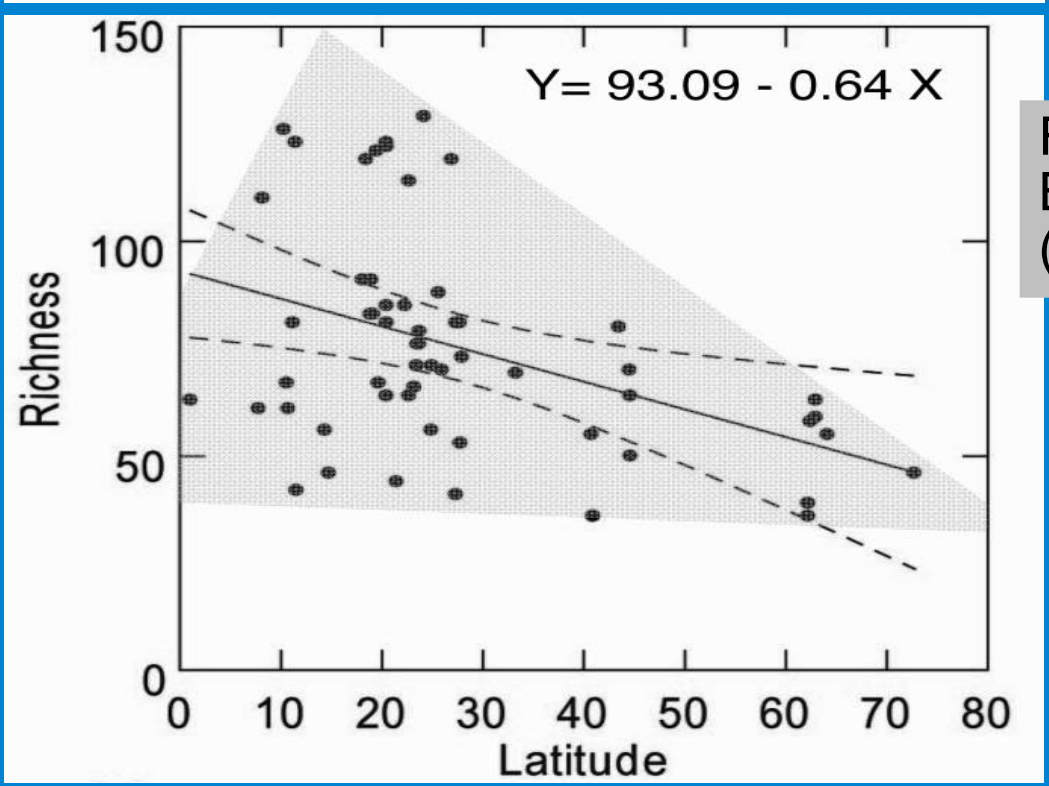
Honjo and Okada (1974)
Pacific coccolithophore diversity

Observed gradients in marine microbial diversity



Pommier et al (2007)
Bacterioplankton
16S RNA

- bacterioplankton
- genomic approaches



Fuhrman et al (2008)
Bacteria
(16S and 23S RNA)

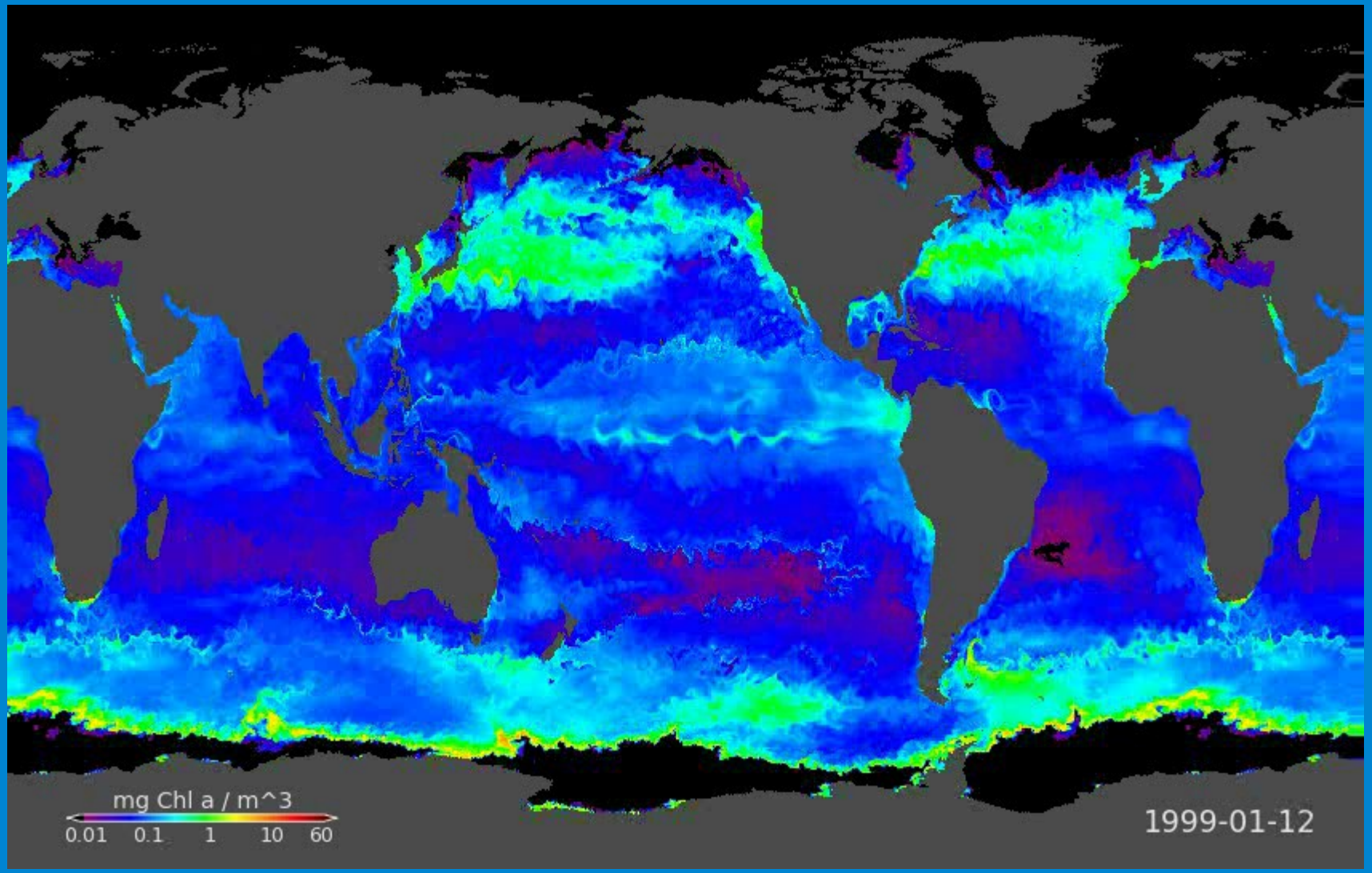
What regulates meridional gradients?

- Variability of environment critical in regulating model's diversity:
  - Seasonal timescales; low diversity
  - Short (synoptic) and long (interannual) timescales; more favorable for co-existence

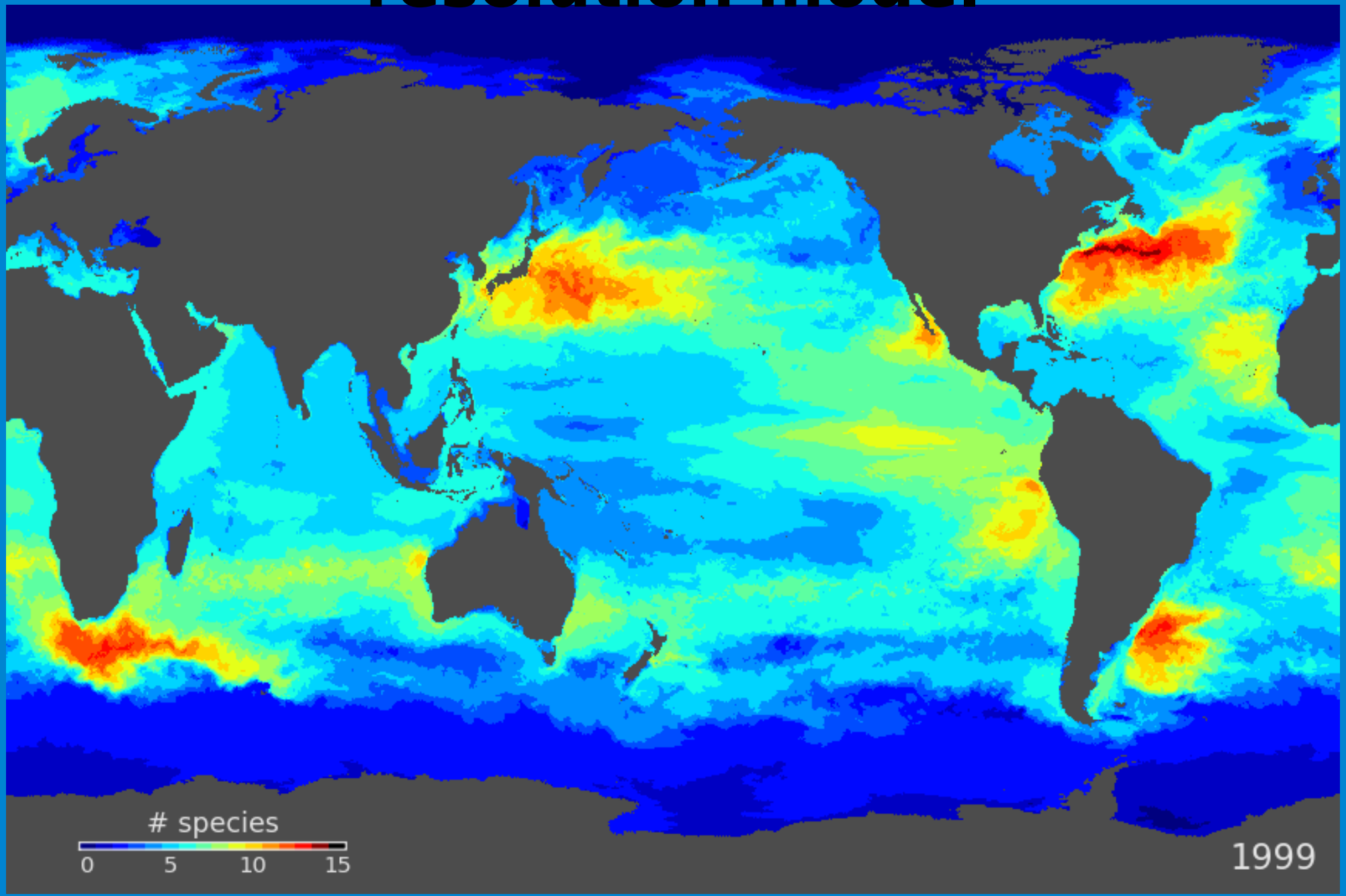
Barton et al – poster B31F-0355

Finer resolution model

- ECCO2 circulation, 18km resolution,
- Self-assembling ecosystem model, 78 phytoplankton types
- **Chlorophyll-a, 1999**

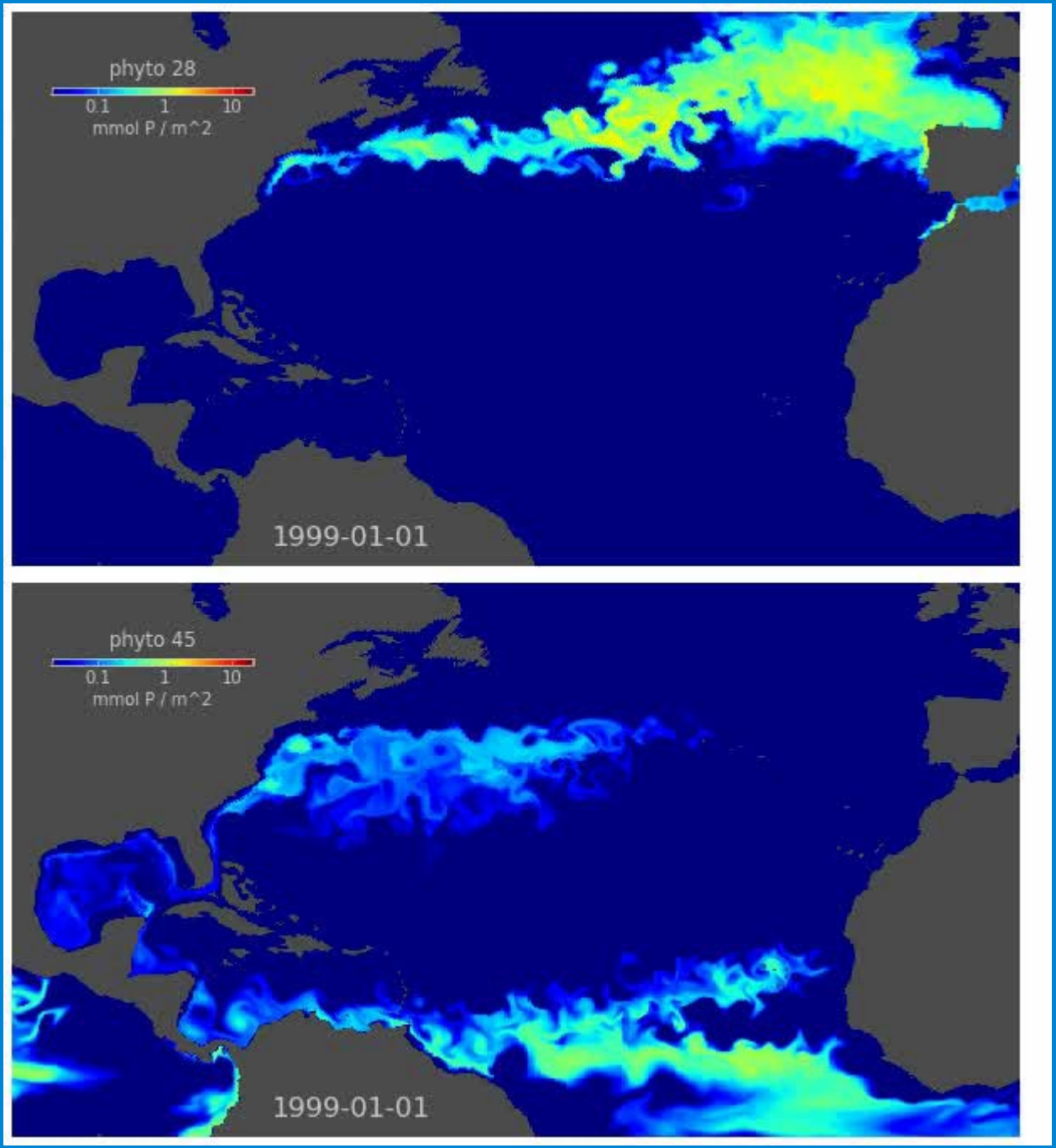


Patterns of Diversity: ECCO2 high-resolution model



Number of co-existing phytoplankton types

Biogeography of two example phytoplankton types

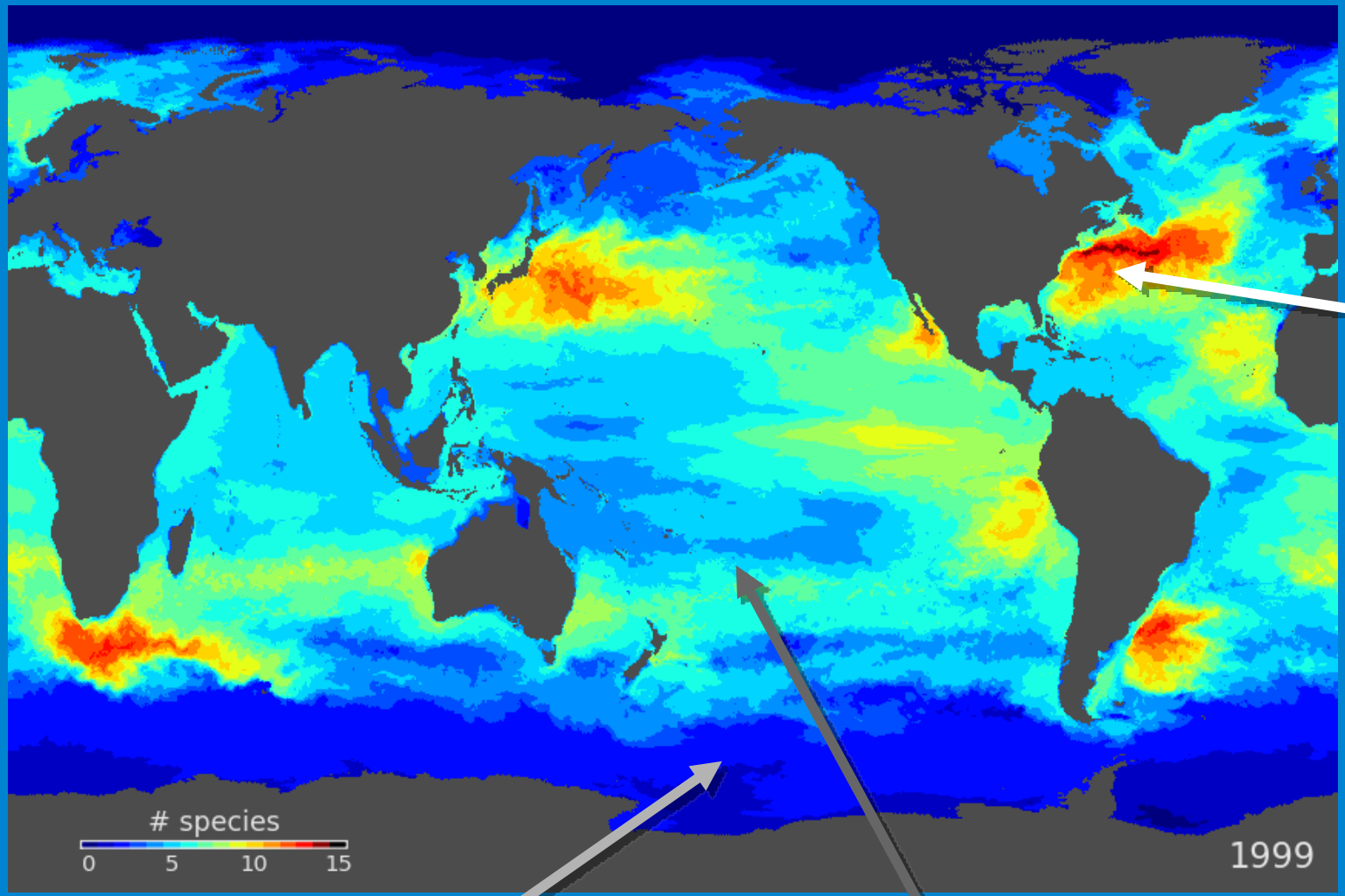


"cold adapted" phenotype

"warm adapted" phenotype

Both contribute significantly to mid-latitude total phyto biomass

Model's mechanisms of co-existence/ diversity

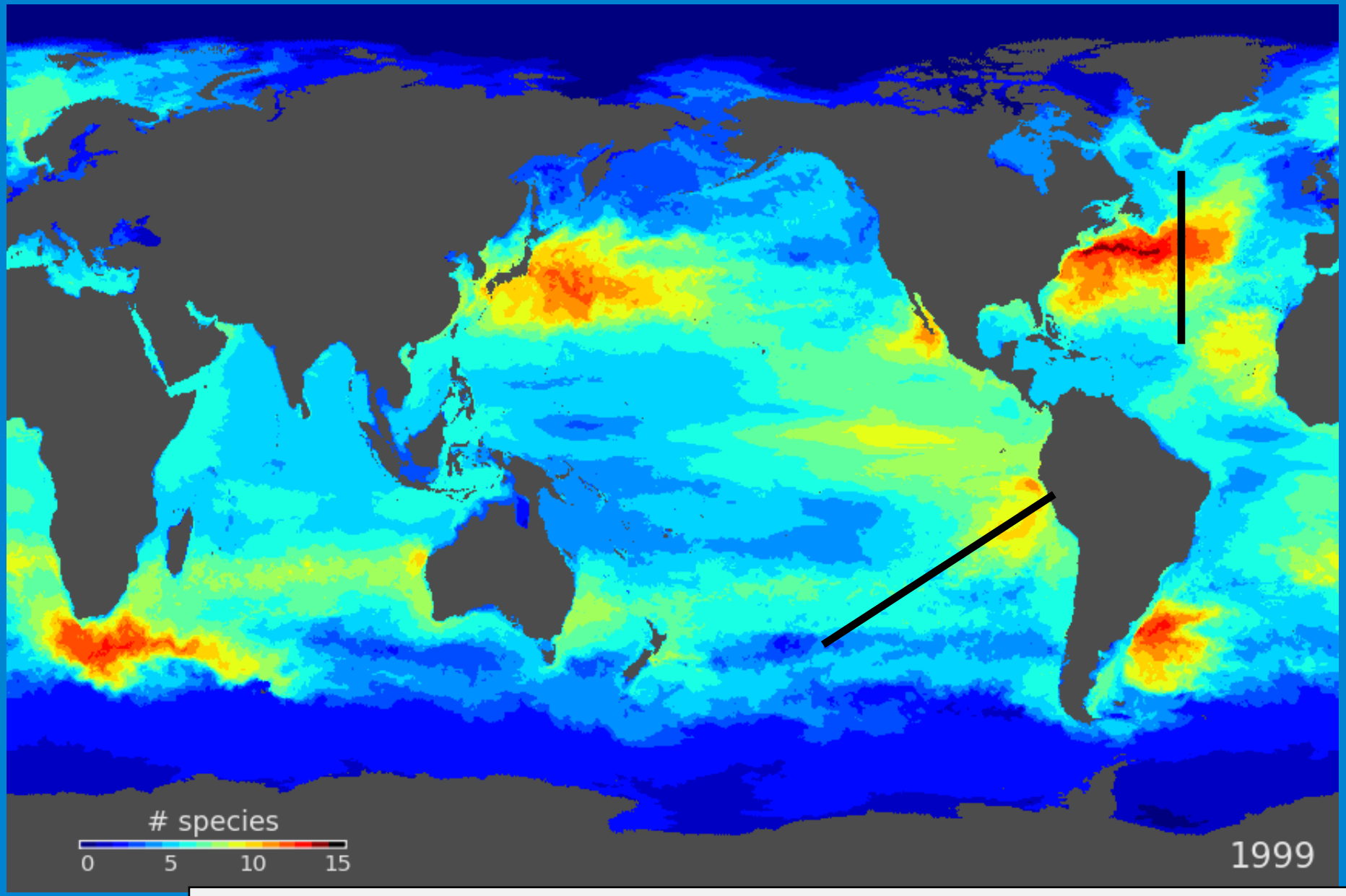


Swift boundary currents
Highest diversity

Strongly seasonal
Very low diversity

Low seasonality
Intermediate diversity

Guiding hypotheses for data analysis & observations?



· Examine historical data sets and target new field observations which cut across regimes

Summary

- “Everything is everywhere, environment selects”
- Self-assembling model phytoplankton communities: Platform for investigation of marine diversity
  - Timescales of environmental variability regulate meridional patterns
  - Advection by swift currents enhances mid-lat diversity
  - Suggest hypotheses for observational strategies

Thanks to
- The ECCO-GODAE and ECCO2 teams
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